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THE NOMENCLATURE OF THE LAKE SUPERIOR FORMATIONS.

"THE Iron Ore Deposits of the Lake Superior Region," by Professor C. R. Van Hise, recently published in the *Twenty-first Annual Report of the United States Geological Survey*, is a most noteworthy contribution to Lake Superior geology. While especially valuable to mining men, for whom it was prepared, its references to stratigraphy are most interesting to geologists. In a footnote (p. 317) it is stated that the evidence upon which the geological succession is based will be fully given in a monograph upon the Vermilion District to be published later. While for the most part in accord with the author's stratigraphy, I do not agree with his nomenclature, and this paper is written with the hope that by discussion unanimity may be reached in this matter also. Owing to its importance, I here quote almost in full the footnote referred to above:

> The foregoing papers render it unnecessary for me here to take up the general stratigraphy of the Lake Superior region. However, our work north of Lake Superior, in northeastern Minnesota and Canada, has upon two points modified our published conclusions as to succession and correlation. Those who compare this paper with earlier papers will note two important modifications. First, the Archean has heretofore been supposed to be composed wholly of igneous rocks; no sediments have been recognized in this division of the pre-Cambrian. The north-shore work, however makes it very probable that certain of the sedimentary iron-bearing formations must be included in the Archean. As examples of such are the productive iron formations of the Vermilion and Michipicoten districts. This modification is important from a theoretical point of view, since it will make changes necessary in my general definition of the Archean and of the Algonkian. The Algonkian has been defined to include all pre-Cambrian sedimentary rocks. The Archean has been defined to include all pre-Algonkian rocks, and has been supposed to contain igneous rocks only. These definitions must be modified so as to include in the Algonkian all pre-Cambrian series which are dominantly of sedimentary origin, or equivalent in age with those which are dominantly of sedimentary origin. The Archean must be defined

to comprise the rocks older than the Algonkian, which are dominantly of igneous origin, but which may include subordinate amounts of sediments. Recent work in northwestern Europe, and especially in Scotland, Scandidinavia, and Finland, where the ancient rocks are best exposed in Europe, shows that these modifications in the definitions of the Archean and Algonkian are also there applicable. The changes are quite in line with what might be expected; for in recent years no one feature in geological advance has been more significant than the sweeping away of sharp dividing lines between the various periods.

Second, the iron-bearing formations of the Vermilion and similar districts I have heretofore regarded as Lower Huronian. In placing these formations in the Archean I recognize three series in which productive ore formations are found, the Upper Huronian, the Lower Huronian, and the Archean.

The evidence upon which these modifications of my opinion concerning Lake Superior stratigraphy are based cannot be here presented in detail. It will be fully given in a monograph upon the Vermilion district, to be published later. In general it may, however, be stated that our work in the Vermilion district of Minnesota and on the Canadian side of the international boundary has convinced us that bands of sedimentary iron-bearing formations are interstratified with the upper part of the oldest series of the Lake Superior region, composed of greenstones, greenstone schist, and tuffs, although the thick productive belts of the Archean appear to rest upon the greenstones and greenstone schists.

Professor Van Hise here lends his weighty support to some views long held by others. It is admitted that true sediments occur in his old Basal Complex, though he does not carry this admission to its logical conclusion and attach the sediments to his Algonkian. Intrusive into these sediments are the granite gneisses of the Complex, a position held by Lawson,[1] Coleman[2] and others. Among these I now place Van Hise, for the Mona and Kitchi schists of Marquette containing banded jasper are pierced by the granites of the Basal Complex according to his description.[3]

The succession held by me is as follows:[4]

1. The Cambrian represented by the Lake Superior sandstone.
2. The Keweenawan.

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[1] *Geol. Sur., Can.*, 1885 and 1887.

[2] *Reports Bur. of Mines, Ont.*

[3] *Mon. U. S. Geol. Sur.*, XXVIII, p. 186.

[4] *Cf. Am. Geol.*, XXVIII, 1901, p. 19.

3. The Animikie, mainly a sedimentary series, but locally containing great series of volcanic rocks.
4. The Upper Huronian, consisting mainly of sedimentary rocks.
5. The Lower Huronian, consisting of green schists and included sediments.

Besides these sedimentary series, the only proper factors in a time scale, there is an immense series of granites and gneisses largely of post-Upper Huronian age, which for convenience of reference have been given the old name Laurentian, a name applied to them when they were believed to represent the basement series.

This succession is almost identical with that given by Van Hise on page 316. The difference between us is largely one of nomenclature. Van Hise writes (p. 317):

> These series are called Huronian because they are believed to be equivalent to the Upper Huronian and Lower Huronian of the original Huronian district north of Lake Huron.

With this correlation I am not in accord. I believe the upper part of the original Huronian to be the equivalent of Van Hise's Lower Huronian, and the original Lower Huronian to be included in his Archean. If this can be substantiated, I have no doubt Professor Van Hise will view my nomenclature favorably, for no one is more anxious than he to recognize the work of Logan and Murray, the founders of the Huronian.

In 1858[1] Logan gave the name "Huronian" to the copper-bearing rocks north of Lake Huron, the distribution of which was being worked out by his assistant, Murray. In 1863[2] he gave a summary of the previous annual reports, and this may be fairly taken as representing his mature views. Detailed sections are given from the Sudbury, Michipicoten, and Mississaga districts. The rocks are mainly sediments, but interstratified with them are beds of amygdaloidal greenstone. Intrusive greenstones and granites are also recognized.

Two slate conglomerates were described separated by a narrow band of limestone. These were practically alike in every particular and Murray found himself unable to distinguish them where the limestone was lacking.[1] The Upper Conglomerate carries occasional pebbles of the limestone when near it, but usually none are to be found. The limestone band as shown in Murray's map is largely conjectural, the outcrops being very few. It seems probable that the break between the two conglomerates is not of great significance and that it would be well not to attempt a separation of them.

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[1] *Rep. Geol. Sur., Can.*, 1857.

[2] *Geol. of Can.*, 1863, pp. 50–66.

Many geologists have argued for a division of the Huronian, though they have not agreed on the horizon. Alexander Winchell[2] places the break at the top of the Lower Slate Conglomerate. Pumpelly and Van Hise[3] place it above the limestone band. The important break must, however, lie much lower. Pebbles of banded jasper and hematite occur in the Lower Slate Conglomerate, in great abundance in places, and must have been derived from some lower sediment. Logan's white quartzite often becomes a conglomerate and is evidently only a phase of the Lower Slate Conglomerate. Excepting the chloritic slates we have, accordingly, in all the lower part of the Mississaga Huronian area evidence of the existence of a lower sediment. The probable occurrence of this banded jasper was recognized by Logan himself, though outcrops were not discovered. This lower conglomerate with jasper and chert pebbles thus becomes of the greatest value in working out Lake Superior stratigraphy, a fact emphasized by Coleman in a paper on the subject.[4] Logan also recognized its value, and correlated slate conglomerates in the Temiscaming, Sudbury, Mississaga, Batchawana, and Michipicoten districts. In describing the Doré series in the last district he mentions[5] pebbles of a "chert-like stone," and near Batchawana Bay jasper conglomerate was found. In maps of both these regions there were included within the Huronian, rocks which are now recognized as the source of the jasper and chert pebbles. In the Temiscaming region, also, banded jaspers, which are the source of the pebbles in the conglomerate, have been found within the area described by Logan as Huronian. Near Sault Ste. Marie banded quartz has been found within the Huronian area.[1]

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[1] *Rep. Geol. Sur.*, 1858, p. 94.

[2] *Bull. Geol. Soc. Am.*, II, 1891.

[3] *Am. Jour. Sci.*, III, 1892, p. 42.

[4] *Rep. Bur. of Mines, Ont.*, 1900, pp. 182–86.

[5] *Geol. Can.*, 1863, p. 54.

There can be no doubt that Logan in 1863 included within his Huronian two series — the one typically represented by the banded jaspers, the other by the slate conglomerate and the jasper conglomerate. This has been uniformly followed from that time forward by all Canadian geologists and by many American, the vertical green schists and their interbedded banded jaspers being considered Lower Huronian. These schists have also been mapped as Huronian in nearly every case by the Canadian Survey. It is true that Lawson, in his reports on the Lake of the Woods[2] and of Rainy Lake, describes similar rocks as Keewatin, doubtfully correlating them with the Huronian north of the Georgian Bay. He recognizes, however, their resemblance to those of the Michipicoten area, a conclusion with which I agree.

The lowest rocks at Michipicoten are greenstones, often ellipsoidally parted, and volcanic tuffs. Interbedded with the latter are cherty iron carbonates, pyritic quartz rocks, ferruginous cherts, and ore bodies. Into these two are numerous intrusions of greenstone and granite. Above lies a slate conglomerate. The resemblance to the Ely greenstone, Soudan iron formation, and Ogishke conglomerate as described by Van Hise[3] is very close. The similarity of the two regions was pointed out by Coleman and Willmot in a paper published in 1899,[4] and it is recognized by Van Hise in the present paper (p. 411).

These schists and interbedded ferruginous sediments have, however, always been considered as Huronian or Keewatin. I see no reason for abandoning the term Lower Huronian for these earliest sediments. Because of the impossibility of separating the sediment from the inclosing greenstones and green schists except on very large scale maps, both will usually be mapped together. This must also be the case for many years over vast areas of Canada until the regions become more accessible. For this reason I doubt the advisability of attempting the separation of the volcanics and sediments except in limited areas of economic value. Here each would be given formational names, just as Van Hise has done with the Ely greenstone and the Soudan iron formation. In other places the volcanics and eruptives will take the name of the sediment with which they are associated. The lowest sedimentary series of the Lake Superior region is the Lower Huronian. These sediments were included in the areas mapped as Huronian by Logan in 1863, and, although not actually found in place by him, were recognized from their fragments, and to him should be given the credit. These rocks have always been mapped as Huronian by the Canadian Survey.

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[1] *Rep. Bur. of Mines*, 1901, p. 187.

[2] *Geol. Sur., Can.*, 1885, I, and 1887, III.

[3] *Iron Ore Deposits of Lake Superior*, p. 402.

[4] *Rep. Bur. of Mines, Ont.*

For these reasons, Lower Huronian is to be preferred to Archean in describing these rocks. Failing Lower Huronian, Keewatin should be adopted, for it too has priority over Archean as used in this connection.

If Lower Huronian is to be substituted for Archean it follows that Upper Huronian would properly replace Van Hise's Lower Huronian. Van Hise correlates (p. 411) the Ogishke conglomerate with the Doré conglomerate, and Logan considered this the equivalent of his Lower Slate Conglomerate. N. H. Winchell[1] and Alexander Winchell[2] both correlate the Ogishke conglomerate with Logan's slate conglomerate. With these correlations I agree on lithological grounds and because of the sequence all around the lake. This may possibly be proved, or at least supported in another way. Coleman has shown, in a paper already referred to,[3] the wide distribution of the slate conglomerates, and that all carry jasper or equivalent pebbles. Barlow has shown[1] that, in the Temiscaming region, the granite-gneisses are in eruptive contact with this conglomerate. I have shown[2] that Murray recognized the eruptive character of the gneiss in connection with his slate conglomerate, though he attempted to explain the facts by faults. I have also shown[3] that at Michipicoten the schist conglomerate is pierced by granite-gneiss. Lawson[4] shows in his Lake of the Woods and Rainy Lake reports that the granite-gneisses are in eruptive contact with the schist conglomerates of his Keewatin.

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[1] *Sixteenth Ann. Rep. Minn. Geol. Sur.*, 1887, pp. 12–40.

[2] *Ibid.*, pp. 145–71.

[3] *Rep. Bur. of Mines, Ont.*, 1900.

We have thus for eight hundred miles across Ontario: (1) a schist conglomerate carrying pebbles of jasper and chert; (2) large areas of granite-gneiss in eruptive contact with it.

It is, of course, possible that these eruptions did not all take place at the same period, but from their magnitude and close connection throughout the whole region it is probable that they did. Taken with the occurrence of a conglomerate carrying such peculiar pebbles as jasper, it may almost be considered proved that all are of the same age. For this reason, in addition to those given above, the original Upper Huronian is considered the equivalent of Van Hise's Lower Huronian.

It follows that the Animikie (and so the Mesabi and Penokee) is younger than the Huronian. This was Logan's position[5] who called the Animikie the lower group of his upper copper bearing rocks. McKellar[6] held on lithological and structural grounds that the Animikie was later than the Huronian. Lawson[7] points out that the conglomerates of his Upper Kaministiquia come out close to the shores of Thunder Bay and form the basement upon which the undisturbed Animikie rocks rest with strongly marked unconformity. Lawson's Upper Kaministiquia I consider Upper Huronian. They are included in the vertical schists which are cut by the eruptive granite-gneisses.

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[1] *Geol. Sur., Can.*, X, p. 91, I.

[2] *Am. Geol.*, XXVIII, 1901, p. 18.

[3] *Ibid.*, p. 16.

[4] *Am. Geol.*, VII, 1891, pp. 320–27.

[5] *Geol. of Can.*, 1863, p. 67.

[6] *Trans. Roy. Soc., Can.*, V, 1887.

[7] *Am. Geol.*, VII, 1891.

In the vicinity of Port Arthur I have found greenish schist with included ferruginous sediments, and also conglomerates carrying pebbles of the first. Both of these have highly inclined dips and have granite-gneiss in eruptive contact with the first at least. The lower series has numerous beds of pyritic quartz rock exactly like the beds in the lowest sediments at Michipicoten. Clearly these two series correspond to the Lower and Upper Huronian, as above defined. Overlying both, and also the granite-gneiss with very gentle dip is the Animikie series.

That the Animikie is later than the Upper Huronian or "Original Huronian," as it is often called, may be shown in several ways:

1. Stratigraphically it is the third series of sediments upwards from the bottom of the geological column in the Lake Superior region — the Upper Huronian is the second.

2. Lithologically, the two series are quite different, and so presumably are of different age. There is very little conglomerate at the base of the Animikie — in the Huronian the quartzites, slate conglomerates, and jasper conglomerates are of great thickness. The oolitic jaspers found in the Animikie are quite absent from the Huronian. The shales, so important in the Animikie, are almost unknown in the Huronian. The laccolitic sills of the Animikie are lacking in the Original Huronian.

3. Structurally, the two series are usually said to be alike in that both lie flat and undisturbed. While this is quite true of the Animikie, it is only partially true of the Huronian north of the Georgian Bay, and is untrue of the Upper Huronian about Batchawana and Michipicoten. Coleman[1] and Murray[2] have described cases of vertical dip within the so-called Original Huronian, and others have been observed by myself. These seem to occur around the outer portion of the Huronian basin, and more gentle dips obtain in the central part. Evidently the Huronian has been subjected to forces which the later Animikie has escaped.

4. Assuming that the large areas of eruptive granite-gneisses

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[1] *Bur. of Mines, Ont.*, 1901, p. 189.

[2] *Geol. Sur., Can.*, 1858, p. 95.

in the Lake Superior region are of the same age, we find that the Upper Huronian has in many cases been pierced by them, but that the Animikie always overlies them.

The conclusion seems inevitable that the Animikie is later than the Upper Huronian. If this is accepted, or if the Upper Huronian is accepted as the equivalent of Van Hise's Ogishke Conglomerate (his Lower Huronian), or if Lower Huronian is accepted as a preferable term for Archean Schist, if any one of these propositions is accepted as proved it seems to me the others should follow.

The succession in Lake Superior would thus be as follows:

Cambrian.
Keweenawan.
Animikie.
Upper Huronian.
Lower Huronian.

It may be urged that because of the enormous time break between the Lower and Upper Huronian, as here defined, the same name should not be applied to both systems. Providing that it is recognized that the terms are descriptive of systems, not of formations, it seems to me that they are quite as appropriate as Lower and Upper Marquette, Lower and Upper Cretaceous, etc. Moreover, in the reconnaissance work in the immense unsettled districts north of the great lakes, it is a distinct advantage to have a general word like "Huronian" to embrace the two systems which are easily separated from the remaining Archean, but are not easily separated from each other. Many areas have been mapped by the Canadian Survey as Huronian, which may or may not contain both systems. That will require more detailed work when the regions become more accessible.

There remains the question of a term of systematic value to designate the pre-Cambrian series. Should they be called Archean, Algonkian, or something else? The Lower and Upper Huronian, and those vast areas of eruptive granite-gneisses, which are mainly of post-Upper Huronian age, undoubtedly represent the old Laurentian and Huronian to which the term Archean was applied by Dana. The Basal Complex to which Van Hise restricted the name when he introduced the term Algonkian, no longer exists. The sedimentary part, with the accompanying volcanics, is in this paper called Lower Huronian. The eruptive granites and gneisses are at least post-Lower Huronian if not post-Upper Huronian in their final consolidation, and must be included with one or the other. There remains nothing below the Lower Huronian to which the term Archean is applicable except the theoretical original crust as yet undiscovered. On the other hand, the continued application of Archean to the rocks known as Huronian and Laurentian, as originally given and as subsequently continued by many, would seem most appropriate.

A. B. WILLMOTT.